in mind that a small but significant percentage of patients undergoing off-pump procedures do require conversion to cardiopulmonary bypass, and in case of urgent conversion, disastrous consequences are recorded at a significant level, marking the scope for urgent off-pump use in a selected group of coronary artery bypass grafting patients.[3]

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doi:10.1016/j.jtcvs.2006.01.059

Reply to the Editor:

We appreciate the interest of Dr Ashraf in our article comparing the outcomes of nonelective on-pump with those of off-pump myocardial revascularization. Dr Ashraf is concerned that our results are not confirmed by well-randomized trials comparing the 2 techniques. However, we are not aware of any randomized controlled trials comparing the outcomes of patients having nonelective off-pump coronary artery bypass grafting (CABG) with those of historical control subjects. Such an endeavor might require randomized trials of impractical size to prove whether statistically significant differences really exist between these 2 techniques of myocardial revascularization in this subset of high-risk patients. The authors also question whether urgent or emergency cases should be handled on a separate basis compared with elective cases. The answer is yes, with the main reason being that urgent and emergency myocardial revascularization poses a greater challenge and has consistently been associated with worse outcomes compared with first elective CABG.[1] Thus a separate and more focused analysis on this subgroup of patients is able to determine the factors that result in a better or worse clinical outcome.

In regard to the issue of decreased rate of postoperative intra-aortic balloon placement and renal failure after off-pump CABG demonstrated in our study, Dr Ashraf quotes a recent article not showing any benefit of off-pump compared with on-pump CABG in regard to the occurrence of postoperative renal function. The study he quotes,[2] however, is a not well-balanced study, including only 158 patients in the off-pump arm and comparing those with 2869 patients having on-pump CABG in the same period of time. One might wonder whether the authors of the study were equally comfortable with both techniques because they performed only about one tenth the off-pump cases compared with on-pump cases. In contrast, our 2-institution study compared 2273 patients undergoing off-pump procedures with 3487 undergoing on-pump procedures and, after a robust statistical methodology, was able to document a lower rate of intra-aortic balloon pump placement and a decreased rate of postoperative renal failure, as well as a decreased length of stay after off-pump compared with on-pump nonelective CABG. Moreover, multiple previous studies, including some randomized controlled studies,[3,4] have documented a lower rate of postoperative renal dysfunction after off-pump compared with on-pump CABG.[5] Finally, we tend to agree with Dr Ashraf that a conversion to cardiopulmonary bypass in cases of urgent myocardial revascularization will be associated with worse outcomes, and thus a careful selection of patients chosen for off-pump surgery by surgeons comfortable with both approaches would be necessary to optimize clinical outcome.

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doi:10.1016/j.jtcvs.2006.02.035

Atrial ablation and esophageal injury: Comments on an experimental study

To the Editor:

In the December issue of the *Journal*, we read with enormous interest the article entitled "Ablation of atrial fibrillation and esophageal injury: effects of energy source and ablation technique" by Aupperle and colleagues.[1] The authors performed in vivo experiments on 39 sheep to evaluate the histologic changes induced in the esophagus by using atrial fibrillation ablation with different energy types, such as cryoablation, microwave, laser, and unipolar or bipolar radiofrequency, through 2 different approaches, endocardial and epicardial. They observed esophageal alterations in numerous cases and concluded that the most significant lesions (moderate and severe damage) were principally induced by endocardial unipolar radiofrequency and cryoablation. We would like to comment on a number of issues.

The esophageal thermal lesion, which is similar to those found in myocardial thermal lesions, is mainly based on the quantity of energy absorbed by the tissue, the type of energy, and the distance between the ablation electrode and the esophagus. Aupperle and colleagues[1] have compared different types of energy applications with standard clinical protocols. However, they do not consider the distance between the electrode and the esophagus or the individual variations in myocardial thickness; that is, no allowance was made for these parameters in the groups under study. Several clinical studies have shown a short anatomic distance between the left atrium and the

esophagus (around 3-5 mm) and a thickness of the myocardium of the posterior atrial wall of around 2 to 3 mm.[2,3] It is thus difficult to obtain valid conclusions with such variations in the endocardium-esophagus distance. Computer simulations using the finite-element method have suggested that the most important factor in esophageal lesions is precisely this distance.[4] In the simulation in which the total distance between the endocardium and the esophagus was fixed, neither variations in the thickness of the linking tissues nor in the thermoelectrical properties had an effect on the thermal pattern.

Regarding the temperature measurement in the esophageal lumen, variations were not found in any case. This result is fairly surprising because there were cases of severe esophageal damage. With regard to this, although temperature monitoring had been proposed as a control method for esophageal lesions during radiofrequency catheter ablation, recent studies have questioned this strategy. Meade and associates[5] showed experimentally that the esophageal temperature failed to increase when the sensors were positioned more than 1.3 cm apart. Effective measuring of the esophageal temperature depends on the position of the temperature probe relative to the heated cardiac tissue and also on good contact with the esophageal mucosa. Therefore the temperature probe, which is advanced under fluoroscopic guidance, should be placed in the optimum position at the level of the ablation lesion. Previous computer results have shown that it is possible to underestimate the maximal temperature reached in the esophagus when the temperature probe is not located exactly under the center of the electrode and on the same plane.[6] This could explain the results obtained by Aupperle and colleagues.[1]

The study concludes that marked lesion were principally induced by endocardial unipolar radiofrequency. In fact, these lesions were small but reached deep into the tissue. It is possible that this conclusion was reached as a result of the higher capability of the irrigated electrodes (bipolar or unipolar) to shift the location of the hottest point toward a deeper zone compared with the case of dry electrodes (bipolar or unipolar).

Finally, it is important to point out that although the acute inflammatory reaction in the lesion caused by cryoablation can be comparable with those created by hyperthermia, it is well known that the lesion is ultrastructurally different and reaches different characteristics in the chronic phase.[7] We do not think that the degree of tissue damage in the hyperthermic lesion is similar to that of the hypothermic lesion, even though both have a similar acute inflammatory reaction from a light microscopy level. Although the esophageal inflammatory reaction described in this study implies a thermal lesion, its clinical outcome is uncertain in the cryoablation case and probably different than those created by the ablation systems based on hyperthermia.

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doi:10.1016/j.jtcvs.2006.02.040

Reply to the Editor:

We have reviewed the letter to the editor from Hornero and Berjano, who presented some comments and questions on our paper.[1] The first points on which they remarked were the definite distance between the esophagus and the atrium in the sheep model, as well as the thickness of the ovine left atrial wall. The model we used has been established and controlled by magnetic resonance imaging.[1] The distance between the esophagus and the atrium (4 mm) showed minimal individual differences (LIT2) and is not responsible for the differences between the groups. As described by Aupperle et al.,[2] the thickness of the atrial wall in the investigated sheep was $3.2+/-0.8$ mm,[2] and variations of the thickniess did not correlate with the effectiveness of atrial ablation.[2,4,5]

Temperature measurement in the esophageal lumen was controlled by palpation to confirm the correct position of the tube, which had several measurement points.[1] The inner mucosal layer was not affected in any case, which makes an incorrect measurement more unlikely but confirms the thesis that the temperature inside the esophageal lumen did not increase. Furthermore, we discussed that the animals' body temperature was decreased (32°C) by the application of endocardial techniques,[1] probably leading to a protection of the tissue.

Clinical reports of human patients described cases of esophageal lesions after atrial ablation after unipolar radiofrequency.[3] These clinical data corresponded well to our findings, that the risk of esophageal lesions in the sheep model was highest after applictaion of endocardial unipolar radiofrequency. The results of the histomorphologic investigations of the ablated hearts in that study[2] showed that endocardial unipolar radiofrequency and cryobalation resulted in sharply demarcated transmural necrosis of the atrial tissue, which did not lead to severe thrombosis. In contrast, laser and microwave energy induced wide non-demarcated transmural lesions and severe thrombosis.

We agree that hypothermically and hyperthermically induced lesions depend on different pathomechanisms,[4] however, in our experiment involving acute lesions, we only could speculate about variations in subsequent wound healing processes. We think that the esophageal lesions, although